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COMPARATIVE VALUE OF WHOLE COTTON SEED AND COTTON-SEED MEAL IN FERTILIZING COTTON.

BY

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LETTER OF TRANSMITTAL.

U. S. DEPARTMENT OF AGRICULTURE,
BUREAU OF PLANT INDUSTRY,
OFFICE OF THE CHIEF,
Washington, D. C., March 5, 1907.

SIR: I have the honor to transmit herewith a paper by Mr. E. B. Boykin, a special agent of the Plant Breeding Investigations of this Bureau, entitled "Comparative Value of Whole Cotton Seed and Cotton-Seed Meal in Fertilizing Cotton."

Notwithstanding the fact that the oil in the cotton seed is its most valuable constituent and that the removal of the oil in no way injures or reduces the fertilizer value of the seed, very many cotton growers still continue to use large quantities of whole cotton seed as a fertilizer. This is a very wasteful practice, as an equivalent value of cotton-seed meal from which the oil has been expressed would have much greater fertilizer value. The opinion, however, prevails among many planters that the whole cotton seed possesses some advantage. Mr. Boykin has conducted experiments to demonstrate the fallacy of this belief, and the results of his experiments, which show the loss from the practice, are reported in this paper. To accomplish its object this paper should be very generally distributed among cotton planters, and I would therefore recommend that it be published in the Farmers' Bulletin series.

Respectfully,

B. T. GALLOWAY,
Chief of Bureau.

Hon. JAMES WILSON,
Secretary of Agriculture.

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COMPARATIVE VALUE OF WHOLE COTTON SEED AND COTTON-SEED MEAL IN FERTILIZING COTTON.

INTRODUCTION.

Cotton in its early history was grown entirely for its fiber, and the value of the seed was unknown. It was considered a difficult problem to find a suitable means of disposing of the seed. The most common way of doing so was to haul it to some remote place or to dump it into some convenient stream, the object being simply to get rid of it with as little trouble as possible. Less than a century ago the seed was considered a nuisance, to be destroyed, while to-day it represents a large proportion of the value of the cotton crop. The seed of a 12,000,000-bale crop is worth nearly $100,000,000 in the raw state. This change in valuation has come about by degrees. The fertilizing value of the seed was first recognized, and until comparatively recent years its only uses have been for planting and fertilizing purposes. However, its uses have been multiplied and its value greatly increased by the very recent development of the cotton-seed oil mills, which is the result of the great value now attached to the oil in the seed. Fortunately, while this oil is adapted to such a great variety of uses and has become such a valuable product, so far as is known at present it possesses none of the ingredients which give to the seed its fertilizing properties. It is composed of carbon, hydrogen, and oxygen, three elements which are essential to plant growth, but which are supplied so abundantly by nature that it is unnecessary to apply them artificially; hence, it is supposed that the fertilizing value of the seed is not diminished by extracting the oil, but that utility is given to a portion of the seed which had none before. Nevertheless, large quantities of seed are still used as a fertilizer without extracting the oil. The value of the oil in an ordinary crop of seed in this country will approximate $60,000,000.

SEED USED FOR FERTILIZER.

Granting that our theory is correct, that the oil has no manurial value, and that it can be extracted from the seed without decreasing its manurial value, it seems that true economy would suggest that it be extracted and this great sum added to the wealth of the country. Statistics show that of the crop of 1905, 61.9 per cent of

the quantity produced was crushed and about 7 per cent was required for planting, leaving 31.1 per cent unaccounted for, which probably was utilized by the growers for fertilizer in the form of seed. The crop of 1905 produced nearly 6,000,000 tons of seed, and approximately 1,800,000 tons were applied to the land as a fertilizer. This contained about 72,000,000 gallons of oil, worth about $18,000,000. Thus it is seen that a large portion of this valuable product is being wasted.

ATTITUDE OF THE OIL MILLS WITH REFERENCE TO CRUSHING THE SEED.

Methods of extracting the oil have been carefully worked out. The oil-mill industry has had a phenomenal growth within recent years. Hundreds of mills have been constructed throughout the cotton belt. They have yielded handsome profits, and the mills would gladly extract the oil from the total supply of seed if they could get it from the growers. Their profits have been so great that they can certainly afford to make terms which the growers can accept. They offer from $9 to $20 a ton for the seed, or from 900 to 1,500 pounds of meal in exchange for a ton of seed. The terms vary according to the time of the season, usually being lowest at the beginning and gradually increasing until the close of the season.

POSITION OF GROWERS AS TO DISPOSAL OF SEED.

Growers differ widely in their opinions as to the best disposition to make of the seed. As shown by the statistics previously quoted, many of them accept the terms offered by the mills. No doubt some of them underestimate the value of their seed and let the mills have it too cheap, while others overvalue it and refuse to let the mills have it at all, when they could do so on profitable terms. The trouble in both cases is that the growers need more accurate information as to the relative fertilizing value of seed. In regions where artificial fertilizers are necessary meal is usually substituted for seed when the seed is disposed of, being obtained in many cases in exchange for seed. The growers can not therefore deal with the mills intelligently without knowing the relative fertilizing value of seed and meal. They need some data to guide them in deciding what terms they can accept from the mills. They need to know how much meal is approximately equivalent in effect on their crops to a given quantity of seed. In order that this information may be obtained and made available for their use the Department of Agriculture is conducting a series of experiments in comparing seed with meal. These experiments are being carried on in connection with Mr. John C. Fletcher's cotton farm at McColl, S. C., and, beginning in 1905, have thus far extended over a period of two years.

POINTS CONSIDERED IN TESTING SEED IN COMPARISON WITH MEAL.

In this work no attempt has been made to solve any technical problems. The object has been to make the test perfectly practical. Seed has been tested in comparison with meal under as nearly as possible the same conditions that exist in the practice of growers. Three tests have been made. Forty bushels of seed to the acre have been tested in comparison with 600 pounds of meal, and 30 and 20 bushels have been compared with corresponding quantities of meal. The quantities of seed tested are probably those most commonly used by growers in general practice. Acre plats were used, as it was thought that results from them would be more reliable than from smaller plats.

CHARACTER OF LAND USED FOR TESTS.

The land selected for the experiments was a dark sandy loam with a clay subsoil and quite representative of a large percentage of the cotton soils requiring artificial fertilizers. It is quite likely, however, that if these tests had been made in the same way on loose sandy or other soils from which the fertilizers can be readily leached out the results would have been different, as much of the meal would probably have been leached out without benefiting the crop, while the seed would have retained its fertilizing constituents much better. However, losses of this kind on such soils can be obviated to a very great extent by applying the readily soluble fertilizers in small quantities at intervals through the growing period. It is regretted that the experiment could not be duplicated on different types of soil.

RELATIVE QUANTITIES OF SEED AND MEAL TESTED.

It was decided that the necessary quantities of acid phosphate and kainit or potash to make a properly balanced fertilizer should be added to the seed in each case. There was some difficulty in determining how much meal should be tested in comparison with the various quantities of seed. However, this was done by estimating what quantity was necessary to make a properly balanced fertilizer with the same amount of acid phosphate and kainit or potash that was employed on the corresponding plats on which whole cotton seed was used as a fertilizer.

LASTING EFFECT OF SEED.

There is a popular belief among growers who advocate the use of seed as a fertilizer that it has a more lasting effect and is more valuable for the permanent improvement of the soil than meal. In order to determine whether or not this theory is correct, the tests were repeated the second year, all the plats being fertilized as they were the

first year, so that the seed plats would have the advantage of any residual effect from the first year's manuring. As will be seen, the results so far do not prove that this theory is correct. However, to make the test more thorough, it is proposed to plant these plats in 1907 with no meal or seed, applying the usual quantity of acid phosphate and kainit or potash to half of each plat and leaving the remaining half without any fertilizer.

RELATIVE AVAILABILITY OF PLANT FOOD IN SEED AND MEAL.

There is a difference in the mehanical condition and the chemical composition of seed and meal, and owing to these differences a season which is entirely suited to one is not likely to be very favorable to the other. The seeds are incased in hulls which must decay before the crop can utilize the plant food in them, and the kernels contain oil which is supposed to retard their decomposition, so that considerable moisture is required to decompose the seed and make available the plant food. In case of a very dry season it does not become available fast enough to supply the crop, and no doubt a portion of it fails to become available until after the crop has matured. On the other hand, the fertilizing material in meal, being in a finely pulverized condition, is more likely to become available during a dry season than that in seed; but when there is excessive rainfall it is liable to become available so fast that the crop can not utilize it and a portion of it will likely be leached out and wasted. It seems, therefore, that seed has an advantage over meal during wet seasons. There was an excessive rainfall during the seasons of 1905 and 1906, but especially in 1906, in the vicinity where these tests were made. This must have favored the seed plats and militated against the meal plats; yet in spite of this condition, as will be seen from Table 1, the results of the tests very strongly indicated the advisability of using meal instead of seed as a fertilizer.

TABLE 1.—*Results of tests with 40 bushels of whole cotton seed in comparison with 600 pounds of cotton-seed meal.*

Field used for test.	Fertilizers used.				Yield in seed cotton.		
	Cotton-seed meal.	Cotton seed.	Acid phosphate.	Muriate of potash.	1905.	1906.	Average for the two seasons.
	Pounds.	*Bushels.*	*Pounds.*	*Pounds.*	*Pounds.*	*Pounds.*	*Pounds.*
Plat 1	600	.....	768	50	2,059	1,396	1,727½
Plat 2	.....	40	768	50	1,897	1,318	1,607½
Difference in yield in favor of meal	.....	.....	.....	.....	162	78	120

In 1904 the land used for these tests was planted to corn and produced about 40 bushels to the acre. A heavy crop of pea vines was also grown on the land and the vines were turned under in the winter

with a 2-horse turn plow. Later the land was laid off and bedded out eight furrows to the row with a 1-horse turn plow. The seed was applied to plat 2 and covered early in the year to prevent germination. All other fertilizers for both plats, including the meal for plat 1, were applied at the time of planting. The crop was cultivated in the usual way. Applications of 768 pounds of acid phosphate and 50 pounds of muriate of potash were made to both the seed and the meal plats.

In 1905 the meal plat produced 2,059 pounds of seed cotton, 162 pounds more than the seed plat, and in 1906 it produced 1,396 pounds, 78 pounds more than the seed plat, making an average of 120 pounds more for the two seasons. To reduce this difference to a money basis it is necessary to consider the relative market value of the seed and meal. At $16 a ton, 40 bushels of cotton seed are worth $9.60, and at $25 a ton, 600 pounds of meal are worth $7.50, or $2.10 less than the seed. This amount added to $4.80, the value at 4 cents a pound of the difference in the yields from the two plats, gives $6.90, the gross difference in favor of the meal. If 75 cents is deducted for picking and preparing for market this extra amount of cotton produced by the meal, there still remains $6.15 as a net average profit from the meal plat more than from the seed plat. It must also be remembered that the 40 bushels of seed contained about 25 gallons of oil, worth about $6.50, and approximately 25 pounds of linters, worth at least $1; so that by using the seed as a fertilizer a quantity of two articles of commerce, having a market value of $7.50, was wasted. Considering the relative market value of meal and seed, the increased yield from the meal, and the loss of oil and linters to commerce, there is a difference in this case of $13.65 per acre in favor of using 600 pounds of meal instead of 40 bushels of seed.

TABLE 2.—*Results of tests with 30 bushels of whole cotton seed in comparison with 450 pounds of cotton-seed meal.*

Field used for test.	Fertilizers used.				Yield in seed cotton.		
	Cotton-seed meal.	Cotton seed.	Acid phosphate.	Kainit.	1905.	1906.	Average for the two seasons.
	Pounds.	*Bushels.*	*Pounds.*	*Pounds.*	*Pounds.*	*Pounds.*	*Pounds.*
Plat 1	450	.....	576	148	2,112	1,343	1,727½
Plat 2	.....	30	576	148	1,809	1,346	1,577½
Difference in yield	.....	.....	.....	.....	303	3	150

In 1904 the land used for these tests produced a crop of cotton of more than a bale an acre. In our experiment it was prepared and cultivated in the usual way. The seed was applied to plat 2 early in the year and the other fertilizers, including the meal for plat 1, were applied at planting time. An application of 576 pounds of acid phos-

phate and 148 pounds of kainit was made to each plat. In 1905 the meal plat produced 2,112 pounds of seed cotton, 303 pounds more than the seed plat, and in 1906 it produced 1,343 pounds, 3 pounds less than the seed plat. In the average production of the two years there is a difference of 150 pounds in favor of the meal.

The 30 bushels of seed at $16 a ton were worth $7.20, and at $25 a ton the 450 pounds of meal were worth $5.62, or $1.58 less than the seed.

This amount, added to $6, the value at 4 cents a pound of the difference in the yields from the two plats, gives $7.58, the gross difference in favor of the meal. If $1 is deducted for picking and preparing for the market the extra quantity of cotton produced by the meal, there is left $6.58 as the net average profit from the meal plat over the seed plat. The oil contained in the 30 bushels of seed was worth about $4.85 and the linters about 75 cents, making approximately $5.60 worth of these products which was wasted. In this test, therefore, there was a difference of $12.18 in favor of using 450 pounds of meal per acre instead of 30 bushels of seed.

TABLE 3.—*Results of tests with 20 bushels of whole cotton seed in comparison with 300 pounds of cotton-seed meal.*

Field used for test.	Fertilizers used.				Yield in seed cotton.		
	Cotton-seed meal.	Cotton seed.	Acid phosphate.	Muriate of potash.	1905.	1906.	Average for the two seasons.
	Pounds.	*Bushels.*	*Pounds.*	*Pounds.*	*Pounds.*	*Pounds.*	*Pounds.*
Plat 1	300	.....	384	25	1,742	1,133	1,437½
Plat 2	.....	20	384	25	1,615	1,084	1,349½
Difference in yield in favor of meal	.....	.....	.....	.....	127	49	88

The land used for these tests is the same kind that was used in testing 40 bushels of seed in comparison with 600 pounds of meal. It produced the same crops in 1904 and was prepared in the same way for the crop of 1905. As usual, the seed was applied early in the season, and the other fertilizers at planting time. An application of 384 pounds of acid phosphate and 25 pounds of muriate of potash was made to each plat. In 1905 the meal plat produced 1,742 pounds of seed cotton, 127 pounds more than the seed plat, and in 1906 it yielded 1,615 pounds, 49 pounds more than the seed plat, making an average of 88 pounds more for the two years. The 20 bushels of seed at $16 per ton were worth $4.80, and at $25 per ton the 300 pounds of meal were worth $3.75, or $1.05 less than the seed. This, added to $3.52, the value at 4 cents a pound of the difference in the yields from the two plats, makes $4.57, the gross difference which was realized in favor of the meal. Taking 57 cents from this amount for the cost of picking and preparing for market the extra cotton produced by the meal, we have $4 as the net average profit from the meal plat over the

seed plat. The oil in the 20 bushels of seed was worth about $3.25 and the linters 50 cents, making approximately $3.75 worth of these products which was wasted. There is therefore a difference here of $7.75 in favor of using 300 pounds of meal instead of 20 bushels of seed.

The comparative results of these fertilizer tests are graphically illustrated in figure 1.

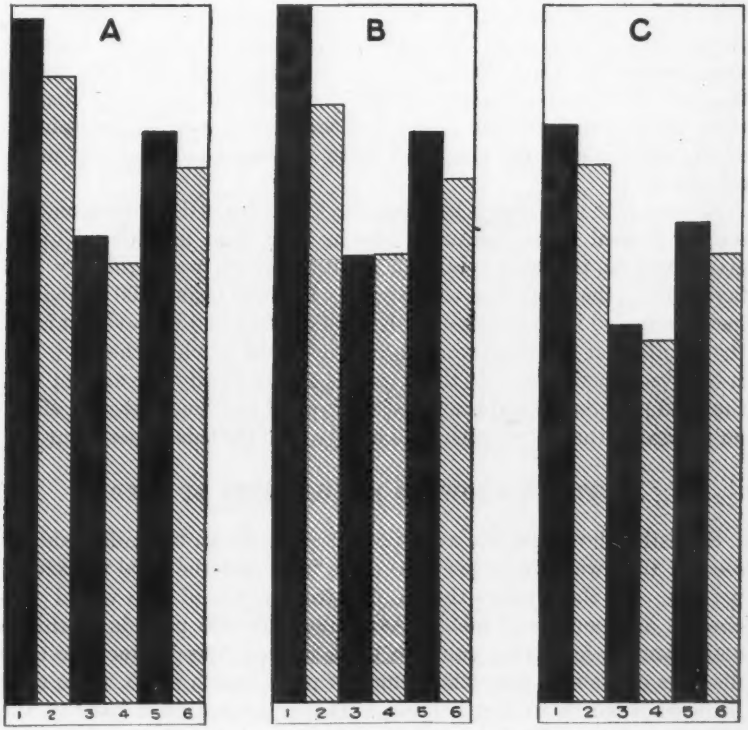

FIG. 1.—Graphic illustration of the relative yields obtained by fertilizing with meal and with seed.

Chart A shows the comparative yields obtained by testing 600 pounds of meal in comparison with 40 bushels of seed. Sections 1 and 3 show the relative yields obtained by using 600 pounds of meal per acre on the same land in 1905 and 1906, respectively. Sections 2 and 4 show the relative yields obtained by using 40 bushels of seed per acre on the same land in 1905 and 1906, respectively. Sections 5 and 6 show the relative average yields for the seasons of 1905 and 1906 for meal and seed, respectively. The land used in this test produced a crop of corn of about 40 bushels per acre in 1904.

Chart B shows the comparative yields obtained by testing 450 pounds of meal in comparison with 30 bushels of seed. Sections 1 and 3 show the relative yields obtained by using 450 pounds of meal per acre on the same land in 1905 and 1906, respectively. Sections 2 and 4 show the relative yield obtained by using 30 bushels of seed per acre on the same land in 1905 and 1906, respectively. Sections 5 and 6 show the relative average yields for the seasons of 1905 and 1906 from meal and seed, respectively. The land used in this test produced a crop of cotton of more than a bale an acre in 1904.

Chart C shows the comparative yields obtained by testing 300 pounds of meal in comparison with 20 bushels of seed. Sections 1 and 3 show the relative yields obtained by using 300 pounds of meal per acre on the same land in 1905 and 1906, respectively. Sections 2 and 4 show the relative yields obtained by using 20 bushels of seed per acre on the same land in 1905 and 1906, respectively. Sections 5 and 6 show the relative average yields per acre for the seasons of 1905 and 1906, respectively. The land used in this test produced a crop of corn of about 40 bushels per acre in 1904.

CONCLUSIONS DRAWN FROM RESULTS OF EXPERIMENTS.

As previously stated, the object of this experiment was to secure data which will enable the growers to estimate how much meal is approximately equivalent to a given quantity of seed in its effect on their crop, and which will guide them in determining what terms they can accept from the mills. Of course, it is impossible to determine what quantity of meal will always be exactly equivalent in effect to a given quantity of seed, as the relative effect will vary with the seasons, some seasons favoring the meal more than the seed, and vice versa. It is believed that the seasons of 1905 and 1906, but especially that of 1906, were more favorable to the seed than to the meal in the vicinity of the experiment, yet the meal plats produced considerably more cotton.

However, the difference between the yields from the corresponding seed and meal plats was much less in 1906 than in 1905. This is attributed to the heavy rainfall of 1906, which was probably less favorable to the meal than to the seed. In these tests 1,000 pounds of meal were used in comparison with 1 ton of seed, and it is evident from the results that less meal would have yielded as much as the seed. It is believed, therefore, that these results amply justify the assumption that 900 pounds of meal is at least equivalent to a ton of seed in effect on the crop; that is, on such land as was used for this experiment.

PROFIT TO GROWERS BY DISPOSING OF SEED.

Statistics show that the average cash price which the mills paid for seed in 1905 was $15.51 per ton, while they sold the meal for $20.35 per ton. At these prices the receipts from a ton of seed would purchase 1,524 pounds of meal. Assuming that 900 pounds of this is equivalent in fertilizing value to 1 ton of seed, the grower who thus disposes of his seed gets 624 pounds of meal, worth $6.95, more than his seed is worth to him per ton. This is figured on a basis of the actual market value of the extra meal obtained, but the results of our experiments clearly indicate that if 1,524 pounds of meal, properly balanced by the necessary amount of acid phosphate and some form of potash, are used as a fertilizer in comparison with a ton of seed to which the necessary acid phosphate and potash have been added, the difference in the resulting profit would certainly be very much greater than the market value of this extra meal, for with this extra meal the growers are enabled at very little extra expense to fertilize their crops much more liberally than if they kept the seed, as the acid phosphate and kainit necessary to properly balance it can be purchased comparatively cheap, and a liberal use of fertilizers almost invariably assures a greater yield and a very much greater profit.

It is very evident that the growers can profitably accept the average terms offered by the mills. Yet many farmers are refusing to do so, and thereby sustain a heavy loss themselves and waste large quantities of oil and linters, which should be turned to profitable uses and increase the wealth of the country. The mills have made large profits, and they should be required to pay for the seed in proportion to the amount of their profits. The growers should get a reasonable portion of the increased value of the seed, and should never dispose of it without getting the equivalent of its fertilizing value plus the cost of hauling it and a reasonable profit on the transaction, which should be proportionate to the market value of the mill products. The cost of hauling varies according to local conditions, but, as a rule, this will not be so great that it will be unprofitable for growers to dispose of their seed on terms by which they realize the equivalent of 1,200 pounds of meal per ton of seed. This, however, is believed to be about the minimum offer which they should accept.

Owing to the increasing value of oil-mill products the mills will no doubt be able to make more favorable terms in the future, or at least will continue to make acceptable terms to the growers for their seed. It is hoped that those growers who underestimate the value of seed and dispose of it without a profit will cease to do this and will hold it for profitable terms, and that those who are refusing profitable terms will see the wisdom of accepting them, not only because of the benefits which they will realize personally, but also because of the immense quantity of valuable products which will be added to the wealth of the country by so doing, which now are being wasted under their present practice of using the whole seed as a fertilizer.

PRESERVATION OF SEED.

There is great necessity for more attention to the proper storing and preservation of cotton seed, as the value of the oil depends upon the condition of the seed when it reaches the mill.

Evidently the products manufactured from the seed would be more useful and more valuable if the seed was kept in good condition. Seed is very easily damaged, especially while green, if stored in large bulks. Large quantities of it reach the mills in very badly damaged condition, thereby causing a great reduction in the value of the products. If the necessary storage room is available, it is very desirable to spread the seed in thin layers over as large a surface as possible, so as to keep it from heating. There is a common practice among growers intending to use their seed for fertilizing purposes to pile it out in the field (fig. 2) as the cotton is ginned and allow it to take the winter's rains. It becomes very hot in these piles and is ruined for oil-mill purposes. While it is intended that seed handled in this

way is to be used as a fertilizer, still conditions might arise which would make it desirable to let the mills have it. This could not be done after such treatment. It is, therefore, preferable to keep the seed in such condition that any disposition can be made of it that seems best at any time during the season. It is also quite likely that seed kept in this way is damaged to some extent for fertilizing

FIG. 2.—Pile of cotton seed retained for fertilizer. (Such piles are commonly seen in the South.)

purposes. So it is evident that this practice should be discontinued, and that greater care should be used in the preservation of the seed.[a]

[a] Since this paper was prepared there has been published Bulletin 75 of the Georgia Experiment Station, in which are reported results of experiments in the use of "Cotton Meal *vs.* Cotton Seed as a Fertilizer" for cotton. The experiments cover a period of two years—1905 and 1906—and the results obtained agree with those reported in Mr. Boykin's paper. The conclusion reached is that it is generally a very unwise practice to use cotton seed directly as a fertilizer or as an ingredient of a fertilizer.—H. J. WEBBER.

FARMERS' BULLETINS.

The following is a list of the Farmers' Bulletins available for distribution, showing the number, title, and size in pages of each. Copies will be sent free to any address in the United States on application to a Senator, Representative, or Delegate in Congress, or to the Secretary of Agriculture, Washington, D. C. Numbers omitted have been discontinued, being superseded by later bulletins.

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